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ELECTROPHYSIOLOGY

Comparison of the Retrograde and Transseptal Methods for Ablation of Left Free Wall Accessory Pathways

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Objectives. The purpose of this study was to compare success rates, procedure and fluoroscopy times and complications for the transseptal and retrograde aortic approaches in a consecutive series of patients undergoing catheter ablation of left free wall accessory pathways.

Background. Radiofrequency catheter ablation of left-sided accessory pathways can be performed either by a retrograde, transaortic approach or by means of a transseptal puncture.

Methods. A total of 106 patients (mean age 33 years, range 4 to 79) underwent attempted catheter ablation of a single left-sided accessory pathway by either the retrograde or the transseptal approach, or both. In the first 65 patients, the retrograde aortic approach was the preferred initial method. In the most recent 51 patients, we first attempted the transseptal approach whenever a physician trained in the technique was available. Ultimately, 102 (96.2%) of 106 patients had successful ablation.

Results. Of 89 retrograde procedures, 85% resulted in elimination of accessory pathway conduction. Four retrograde procedures performed after failure of the transseptal approach were successful. Of the 13 patients with a failed retrograde procedure, 11 later underwent ablation using the transseptal approach. Twenty-six (85%) of 33 transseptal procedures were successful. All four patients with unsuccessful initial transseptal attempts were successfully treated with the retrograde method during the same session in the electrophysiology laboratory. Ten of 11 transseptal procedures after unsuccessful retrograde procedures were successful. Crossover from the retrograde to the transseptal approach was performed during a separate session in 9 of these 11. There was no difference in total procedure time (220 ± 12.8 vs. 205 ± 12.5 min) (mean ± SEM) or fluoroscopy time (44.1 ± 4.4 vs. 44.7 ± 5.1 min) between the retrograde and transseptal methods. Ablation time was longer for the retrograde method (69.2 ± 10.5 vs. 43.4 ± 9.3 min) ($p < 0.01$). Of patients ≥65 or ≤16 years old, technical factors requiring crossover to the other technique or complications occurred in 7 (42%) of 17 patients undergoing the retrograde and 1 (11%) of 9 patients undergoing the transseptal approach ($p < 0.01$). The overall rate of complications was the same for both (6.7% for retrograde and 6.1% for transseptal). The most serious complication involved dissection of the left coronary artery with myocardial infarction during a retrograde procedure.

Conclusions. The retrograde and transseptal approaches are complementary; if one method fails, the other should be attempted, yielding an overall success rate close to 100%. Because patients undergo heparinization immediately after the arterial system is entered during a retrograde procedure, failure of that approach requires crossover to the transseptal method during a separate session or reversal of heparin; if the transseptal method is tried first, crossover to the retrograde approach can be accomplished easily during the same session. To avoid complications related to access, the transseptal method should be the first used in children, the elderly and those with arterial disease or hypertrophic ventricles.

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Radiofrequency catheter ablation has gained wide acceptance in the treatment of adults (1–5) and children (6) with symptomatic supraventricular tachycardia involving an accessory atrioventricular (AV) connection. Ablation of left free wall accessory pathways requires that the tip of the ablation catheter be positioned at a target site along either the atrial or the ventricular surface of the mitral annulus. In most reports the mitral annulus has been approached by inserting a catheter through the femoral artery and advancing it retrograde across the aortic valve. Although achieving a high efficacy rate, such an approach has the potential for complications related to arterial access and the need to pass a relatively stiff 7F or 8F catheter across the aortic valve (7,8) and in close proximity to the ostia of the coronary arteries. Alternatively, preliminary reports (9,10) have described access to the atrial aspect of the mitral annulus obtained by way of transseptal catheterization, which may

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avoid potential problems associated with the retrograde approach.

The purpose of this study was to compare the success rate, procedure and fluoroscopy times and incidence of complications for the transseptal and retrograde aortic approaches in a consecutive series of patients undergoing radiofrequency catheter ablation of a left free wall accessory pathway.

Methods

Patients. From April 1990 to April 1992, a total of 195 patients underwent attempted radiofrequency catheter ablation of one or more accessory AV connection. A total of 106 of these patients had attempted catheter ablation of a single left-sided accessory pathway by either the retrograde aortic or transseptal approaches, or both, and are the subjects of this report. Three patients with multiple accessory pathways are not included because their small number make a meaningful comparison of approaches impossible. The mean age of the patients was 33 ± 0.2 years (range 4 to 79; 62 male, 44 female patients). Twenty-eight patients had a concealed accessory pathway, and 78 had manifest pre-excitation. Nine patients had structural heart disease known before the ablation procedure, including four patients with coronary artery disease, two with mitral valve prolapse and one each with hypertrophic obstructive cardiomyopathy, aortic stenosis and a small ventricular septal defect.

Electrophysiologic testing. After giving informed written consent, all patients underwent an abbreviated electrophysiologic study followed by the ablation procedure in the postabsorptive, mildly sedated state in the manner previously described (1). The purpose of the electrophysiologic study was to assess the anterograde and retrograde conduction and refractory properties of the normal and extranodal AV connections and to verify the involvement of the accessory pathway in any induced tachycardia. Preliminary mapping was performed with a quadripolar or hexapolar catheter in the coronary sinus before proceeding to more precise mapping with the ablation catheter.

Retrograde aortic approach. In the first 65 patients, the retrograde aortic approach was the preferred initial method. After preliminary mapping in the coronary sinus confirmed the presence of a left-sided accessory pathway, a 7F or 8F tip-deflecting bipolar or quadripolar catheter with a 4-mm distal electrode and 2- to 5-mm interelectrode spacing (Mansfield/Webster or EP Technology) was inserted through a sheath in the femoral artery, advanced retrograde and prolapsed through the aortic valve. All patients underwent full heparinization with 80 to 150 U/kg body weight, with additional doses administered during the procedure as necessary.

Once the catheter was placed in the left ventricle, it was advanced and the tip deflected to target sites under the mitral valve as close as possible to the annulus, except in five patients in whom the catheter was more easily advanced to the atrial side of the annulus. Initial target sites were chosen on the basis of mapping within the coronary sinus. The ablating catheter was then manipulated to a site that had the shortest interval between the local atrial and ventricular electrograms and the earliest ventricular activation during sinus rhythm or atrial pacing in the case of manifest pre-excitation and the site of the earliest retrograde atrial activation during orthodromic reciprocating tachycardia or ventricular pacing. Deflections arising from the accessory pathway itself (11) were not explicitly sought.

At target sites, 20 to 50 W of unmodulated radiofrequency energy (EP Technology) was delivered for 10 to 60 s between the tip of the ablation catheter and a large surface area skin electrode. If a sudden increase in impedance occurred during energy application, energy delivery was automatically discontinued, the catheter removed and adherent coagulum cleaned from its tip. If an application of radiofrequency energy failed to abolish anterograde and retrograde conduction over the accessory pathway, the catheter was repositioned and the procedure repeated.

Transseptal approach. Because several groups had reported encouraging preliminary results of ablation of left free wall accessory pathways by the transseptal route (9,10), and because several of our patients had complications related to access by the arterial approach, in the most recent 51 patients, we first attempted the transseptal approach whenever a physician trained in the technique was available. Although we did not formally randomize patients to one or the other method, two of us were trained in the transseptal method, so that this method was the first attempted in 21 patients, and the remainder continued to have the retrograde method used. No attempt was made to select specific patients for one or the other method. When crossover to the transseptal method after failed retrograde approach was required, a physician experienced with transseptal puncture performed that procedure.

A diagnostic electrophysiologic study with initial mapping in the coronary sinus was performed in the same fashion as described for the retrograde approach. During eight procedures, the fossa ovale was successfully probed with the ablation catheter, and a foramen ovale was crossed directly. In the remaining patients, preparations were made for a transseptal puncture, as follows. A 5F pigtail catheter was introduced through a 5F femoral artery sheath and advanced to the aortic root to aid in visualizing the proper site for a transseptal puncture. Ten to 15 ml of radiocontrast agent was injected through the pigtail catheter to outline the extent of the aortic root and then flushed with heparinized saline solution every 2 min until successful transseptal puncture occurred. Using right and left anterior oblique or anteroposterior and lateral biplane fluoroscopic projections, transseptal puncture was performed using a Brockenbrough needle (12) under continuous monitoring of pressure. Several milliliters of contrast agent was injected to confirm that the needle tip was in the left atrium. An 8F Mullins sheath (13) (USCI/Bard, Inc.) was advanced over the needle, and the needle and dilator were removed, leaving the sheath in the left atrium.

Patients underwent full heparinization after successful transseptal catheterization, and a 7F or 8F tip-deflecting catheter with a 4-mm distal electrode was passed through the Mullins sheath into the left atrium. Target sites were sought along the atrial aspect of the mitral annulus using the same criteria described for the retrograde approach. At target sites, 20 to 50 W of unmodulated radiofrequency energy was delivered for 10 to 60 s between the tip of the ablation catheter and a large surface area skin electrode. If a sudden increase in impedance occurred, the catheter was removed. If an application of radiofrequency energy failed to abolish conduction over the accessory pathway, the catheter was repositioned and the procedure repeated.

Definitions. For purposes of comparing approaches, a *procedure* was defined as an attempt to ablate an accessory pathway by one of the two methods, and a *session* was defined as a single visit to the electrophysiology laboratory. Thus, a patient may have had more than one procedure (e.g., unsuccessful transseptal and successful retrograde) in the same session or multiple sessions using the same or different approaches. Although this was not a randomized trial, the temporal sequence of procedures and sessions and the reason for crossover from one approach to the other were tracked for all patients.

The duration of several aspects of the procedure was logged. These included *total procedure time*, defined as the time elapsed between the patient's entry into the electrophysiology laboratory and catheter removal. For patients with multiple procedures during a given session, the elapsed time for each was logged separately. *Ablation time* was elapsed time from initiation of mapping with the ablation catheter until the last radiofrequency pulse. Ablation time was included in our analysis because we considered it the best quantitative measure of the ease with which an ablation catheter could be manipulated to a desired location on top of or under the mitral annulus. *Fluoroscopy time* was recorded automatically during the procedure and was the sum of exposure time for anteroposterior and lateral fluoroscopic studies.

Statistical analysis. Group values are presented as mean value ± SEM. Comparisons between variables were made using a two-tailed *t* test or chi-square analysis. A p value < 0.05 was considered significant.

Results

The 106 study patients underwent a total of 122 procedures during 114 sessions in the electrophysiology laboratory. Ultimately, 102 (96.2%) of the 106 patients had successful, complete elimination of accessory pathway conduction.

Retrograde approach. Figure 1A details the results of those patients undergoing an attempt at accessory pathway ablation using the retrograde, transaortic method. Of 89 retrograde procedures, 76 (85%) resulted in successful elimination of accessory pathway conduction. Of these 89 procedures, 85 were performed as an initial attempt and 72 (85%) were successful. In five cases, the ablation catheter advanced easily into the left atrium by the retrograde approach, and ablation on top of the mitral annulus was successful in all. Four retrograde procedures performed after initial failure of the transseptal approach were successful. Of the 13 patients with a failed retrograde procedure, 11 underwent subsequent attempts at ablation using the transseptal approach. In 1 of these 11, a patent foramen ovale was successfully crossed directly with an ablation catheter. In another, because it was inadvisable to perform a transseptal puncture in a patient who had undergone full heparinization for retrograde left ventricular catheterization, protamine was administered to reverse heparin before a transseptal puncture was performed during the same session. This patient had a reaction to the protamine that seemed to initiate incessant supraventricular tachycardia. Therefore, in the remaining 9 of these 11 patients, the transseptal approach was performed in a separate session.

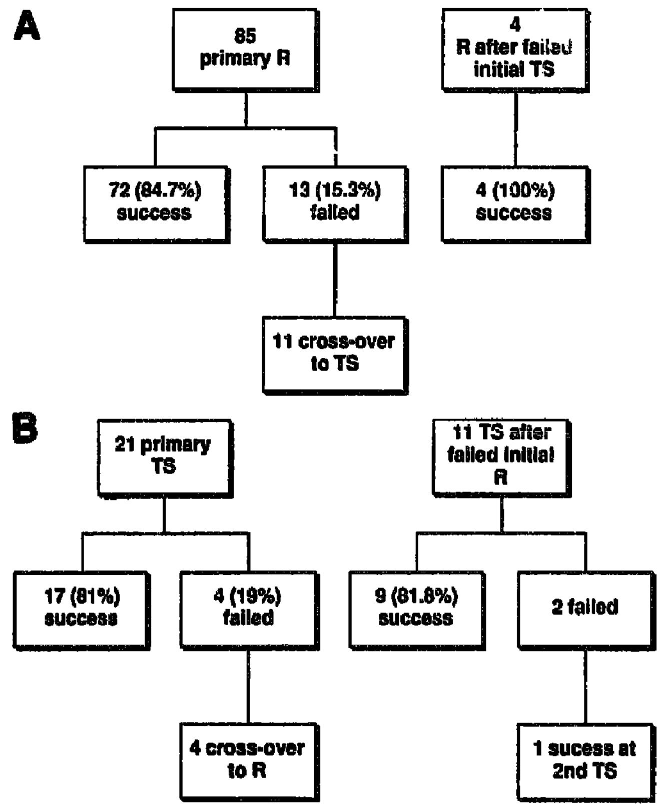

Figure 1. Tree diagrams detailing the outcome of (A) 89 retrograde, transaortic procedures (overall success rate 85.4%) and (B) 33 transseptal procedures (overall success rate 84.8%) for ablation of left free wall accessory pathways. R = retrograde procedure; TS = transseptal procedure.

Successful ablation by way of the retrograde approach was accomplished in a median of five applications of radiofrequency energy (mean 7.1 ± 0.91). The atrial/ventricular electrogram ratio at successful sites was 0.22 ± 0.08 (exclud-

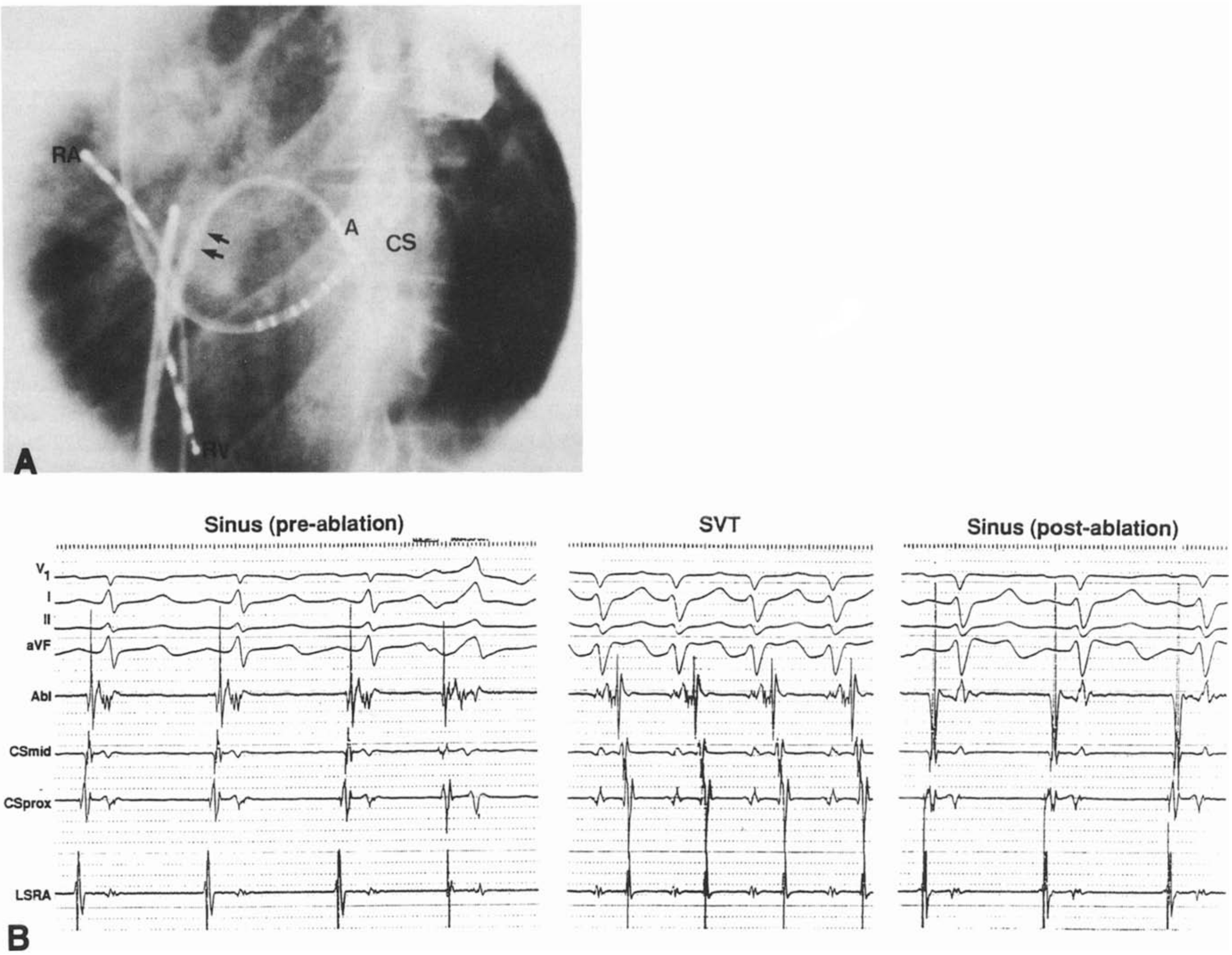

Figure 2. A, Left anterior oblique cineradiographic image taken during transseptal ablation of a left lateral accessory pathway. Catheters are seen in the high right atrium (RA), right ventricular apex (RV) and coronary sinus (CS). Arrows mark the outline of a sheath in position across the atrial septum. A large-tipped steerable ablation catheter (A) has been passed through the transseptal sheath and positioned along the atrial aspect of the lateral mitral annulus. B, Surface electrocardiographic leads V_1, I, II and aVF and intracardiac electrograms from the ablation catheter (Abl) at the site of successful ablation along the lateral mitral annulus, mid (CSmid) and proximal (CSprox) coronary sinus and low septal right atrium (LSRA). All electrograms were filtered with a passband of 30 to 250 Hz. Left, Sinus rhythm before ablation; the last complex is a spontaneous atrial premature beat with an enhanced degree of pre-excitation. Center, The same recording sites during orthodromic reciprocating supraventricular tachycardia (SVT) at a cycle length of 370 ms. The electrogram recorded from the ablation catheter has fused atrial and ventricular components during both sinus rhythm and tachycardia, with a central high frequency component possibly representing Kent bundle activation. Right, Sinus rhythm after successful ablation of the left lateral accessory pathway. The atrial and ventricular components are now widely separated.

ing the five patients who had successful ablation of the atrial aspect of the mitral annulus by way of the retrograde approach).

Transseptal approach. The results of the transseptal method of accessory pathway ablation are shown in Figure 1B. Overall, 26 (85%) of 33 attempted transseptal procedures were successful. Of the 21 transseptal procedures performed as an initial attempt, 17 (81%) resulted in successful elimination of accessory pathway conduction. All four patients with a failed initial transseptal procedure crossed over to the retrograde method during the same session. Eleven transseptal procedures were performed after patients had unsuccessful retrograde procedures, and 10 (91%) of 11 ultimately had successful elimination of accessory pathway conduction, with one patient requiring two transseptal procedures during separate sessions because of recurrence of pre-excitation 24 h after apparently successful ablation.

Successful ablation by way of the transseptal approach was accomplished in a median of four applications of radiofrequency energy (average 7.7 ± 1.3) (p = NS compared with the retrograde method). The atrial/ventricular electrogram ratio at successful sites was 0.65 ± 0.45 ($p < 0.01$ compared with the retrograde method). Figure 2 shows, for a typical patient undergoing transseptal ablation, a cineradiographic image along with electrograms recorded from the successful ablation site during both sinus rhythm and ortho-

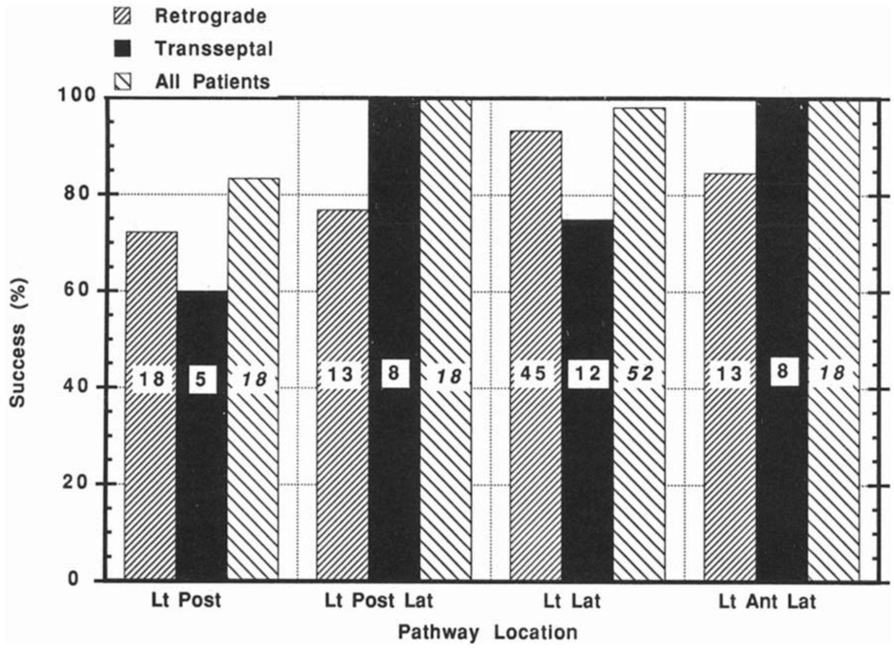

Figure 3. Graph comparing success rates for the retrograde and transseptal approaches for accessory pathway locations around the mitral annulus. The numbers on the bars for patients who underwent the retrograde or transseptal approach indicate the total number of procedures performed using that method for a given accessory pathway location. The bars for "all patients" indicate the ultimate success rate for patients with a given pathway location, and the numbers on the bars indicate the total number of patients with an accessory pathway in a given location. Lt Ant Lat = left anterolateral; Lt Lat = left lateral; Lt Post = left posterior; Lt Post Lat = left posterolateral.

dromic reciprocating tachycardia before ablation and during sinus rhythm immediately after ablation.

Factors related to ablation success by method. Although this study was not randomized, there was no attempt to specifically select patients for one or the other procedure on the basis of any demographic or clinical factor. There was no significant difference in the percent of male versus female patients undergoing an initial attempt at ablation using the retrograde approach (72% vs. 77%). The average age of patients undergoing an initial attempt using the retrograde approach was not significantly different from that of patients undergoing an initial transseptal procedure (33.2 ± 0.8 vs. 34.1 ± 2.1 years).

Several clinical and electrophysiologic factors were analyzed to determine under which circumstances, if any, one method should be preferred. Ablation of concealed versus manifest pathways did not differ significantly in success rate by method. Nine (90%) of 10 transseptal and 19 (86.4%) of 22 retrograde procedures performed for ablation of concealed accessory pathways were successful (p = NS). Eighteen (78.3%) of 23 transseptal and 61 (91%) of 67 retrograde procedures for manifest accessory pathways resulted in successful elimination of accessory pathway conduction (p = NS). Eleven (78.6%) of 14 transseptal procedures and 34 (94.4%) of 36 retrograde procedures performed in female patients were successful (p = NS), whereas 16 (84.2%) of 19 transseptal and 46 (86.8%) of 53 retrograde procedures in male patients were successful (p = NS).

We examined the success rate by accessory pathway location. Figure 3 details the success rate of each method, as well as the ultimate success rate for all patients, for pathway location around the mitral ring from left posterior to left anterolateral. Although these groups were in some cases too small for statistical comparison, there was a tendency for the transseptal approach to be favored for accessory pathways in the posterolateral and anterolateral positions and for the retrograde method to have a higher success rate with posterior and directly left lateral accessory pathways.

Of patients ≥65 or ≤16 years old, technical factors requiring crossover to the other technique or approach-related complications (see later) occurred in 7 (42%) of 17 patients undergoing the retrograde approach compared with 1 (11%) of 9 patients undergoing the transseptal approach ($p < 0.01$).

Time comparisons. There was no significant difference in total procedure time (220 ± 12.8 vs. 205 ± 12.5 min) or fluoroscopy time (44.1 ± 4.4 vs. 44.7 ± 5.1 min) between retrograde and transseptal methods. Ablation time, however, was on average significantly longer for the retrograde compared with the transseptal method (69.2 ± 10.5 vs. 43.4 ± 9.3 min) ($p < 0.01$). The potential for a "learning curve" effect exists for these results insofar as most of the transseptal procedures were performed during the more recent half of the series. To minimize this phenomenon, we also compared procedure times for the 20 most recent procedures performed by each method, and the results were similar to those of the entire series. There was no significant difference in total procedure time (214 ± 15 vs. 199 ± 13 min) or fluoroscopy time (41.9 ± 4.5 vs. 43.3 ± 5.6 min) between retrograde and transseptal methods. Ablation time for the 20 most recent retrograde procedures remained significantly longer than that for the 20 most recent transseptal procedures (49 ± 8.9 vs. 32.6 ± 7.8 min) ($p < 0.01$).

Factors responsible for crossover. For each case in which a failure by one method necessitated crossover to the other, we sought the factor responsible. Factors responsible for crossover from the retrograde to the transseptal method included repeated recurrence of arrhythmia after transient success in two patients, both of whom had two retrograde procedures each during separate sessions; a small ventricle in one child and a hypertrophic ventricle in two adults in whom placing the tip of the ablation catheter along the ventricular aspect of the mitral annulus was hampered because of difficulty in catheter manipulation; aneurysmal aorta in two patients in whom it became difficult to transmit torque to the catheter tip (in one, the catheter was of insufficient length to cross the aortic valve); a large femoral arterial hematoma in one patient requiring premature termination of the procedure, and, in two patients, inability to position the catheter at the mitral annulus near the left fibrous trigone for anterolateral accessory pathways.

Factors responsible for crossover from the transseptal to the retrograde method included repeated recurrence of arrhythmia after transient success in two patients and failure to cross the septum in two patients.

Complications. There was no difference in the incidence of significant approach-related complications between methods, occurring in 6 (6.7%) of 89 retrograde and 2 (6.1%) of 33 transseptal procedures. Most of the complications during the retrograde approach were attributable to arterial access, with significant groin hematomas during four procedures and a peripheral embolism that resolved spontaneously in one patient. The most serious complication during a retrograde procedure was dissection of the left main coronary artery. In this patient the ablation catheter tip lodged briefly in the left coronary artery during an attempt to prolapse the catheter across the aortic valve. The procedure continued without difficulty, and a left lateral accessory pathway was successfully ablated; however, 12 h after the procedure the patient had electrocardiographic (ECG), echocardiographic and enzymatic evidence of an anterior and septal wall myocardial infarction. A coronary angiogram revealed a dissection and contained perforation of the left main coronary artery with an extrinsic hematoma compressing and significantly obstructing the left anterior descending coronary artery. A repeat angiogram 2 days later showed the left anterior descending artery to again be patent, but 3 months later, the patient although asymptomatic, underwent surgical repair of an expanding pseudoaneurysm of the left main coronary artery.

Early in our experience with the transseptal method, transient air embolization to the right coronary artery occurred after a catheter exchange when inadequate fluid flush was applied through the Mullins sheath. Coronary artery spasm during radiofrequency application was strongly suspected in another patient undergoing ablation of a left anterolateral accessory pathway by the transseptal approach. The patient reported chest pain, which was accompanied by ST segment elevation immediately after radiofrequency application (and 30 min after uncomplicated transseptal puncture). The chest pain and ECG changes resolved within 2 min after the administration of sublingual nitroglycerin. Coronary angiography performed within 10 min was normal, and the patient did not develop ECG q waves or an elevation of creatine kinase levels, and has done well clinically.

There were no complications related solely to transseptal puncture.

Echocardiograms were performed on all patients 24 to 48 h after the ablation procedure. No patient developed new mitral regurgitation, thrombi at the site of ablation or evidence of an atrial septal defect. One patient who had undergone a retrograde procedure developed Doppler evidence of mild aortic insufficiency but has remained asymptomatic 2 years after the procedure. Two patients, both of whom had had a retrograde procedure, developed pericardial tamponade at the end of the procedure when the right ventricular apex catheter was removed. In both cases this was at least 45 min after the last application of radiofrequency energy, and it seemed likely that the cause in both was neither the specific approach used nor application of radiofrequency to the endocardium but perforation of the pacing catheter in the right ventricle in patients who had undergone anticoagulation. Both patients were treated successfully with pericardiocentesis.

Follow-up. Of the four patients with unsuccessful ablation, one has undergone successful surgical ablation of accessory pathway, and three are maintained on antiarrhythmic drug therapy. Three of the four patients with unsuccessful ablation had undergone attempted retrograde procedures only, without crossover to the transseptal method. All four were within the first 30 patients in our series, and inexperience may have played some role in these failed procedures. One patient had had a previous attempt at direct current shock ablation in the mouth of the coronary sinus for a left posteroseptal accessory pathway, and scarring from this procedure may have altered the anatomy.

Three patients, two with a retrograde and one with a transseptal procedure, had recurrence of tachycardia or pre-excitation 1, 2 and 40 days, respectively, after an apparently successful procedure. All had successful repeat ablation, and these repeat procedures are included in the analysis described earlier. Since the close of this study, the patients have been followed up for a mean of 19.4 ± 0.6 months, and none have had recurrence of tachycardia or pre-excitation. There have been no new, late-appearing complications during follow-up.

Discussion

Success rate and procedure time comparisons. The main finding of this study is that both the retrograde aortic and transseptal approaches can be safely and successfully employed to ablate left free wall accessory pathways. Although the success rate of either approach was 85%, because both techniques were available to our patients, the overall rate of successful therapy was 96.2%. Total procedure and fluoroscopy times were similar, but ablation time was significantly shorter for the transseptal method. The likely explanation for this finding is that whereas performing a transseptal puncture required a bit more time than obtaining arterial access, catheter manipulation during mapping was easier along the atrial than along the ventricular aspect of the mitral annulus. To move the tip of the ablation catheter even incrementally once it is lodged under the mitral valve during a retrograde procedure requires withdrawing the catheter until it is free of the mitral apparatus. In contradistinction, during transseptal ablation the tip of the ablation catheter can be swept incrementally, unobstructed, along the atrial surface of the annulus.

Either method can be used for all left-sided pathway locations. There was a higher success rate of the transseptal approach for pathways in the posterolateral and anterolateral positions, possibly because mitral valve commissures at those locations make the annulus somewhat less approachable from under the mitral valve in some patients. However, the numbers in each subgroup are small, and definite conclusions cannot be statistically supported. Concealed pathways were ablated with equal success by either method.

We had analyzed our results on an intention-to-treat basis; however, in two patients failure of the transseptal method was due not to inability to map and ablate along the atrial aspect of the mitral annulus but to an inability to easily puncture the septum. If these patients are excluded from the analysis, then the success rate of the transseptal method for those patients in whom the left atrium was entered increases to 28 (90.3%) of 31. These results are similar to those of Swartz et al. (14), who report a success rate of 95% for 76 patients treated by the transseptal method with only a single serious complication. In our series, there was an equal or higher success rate for secondary procedures (those performed after failure of the alternative approach) than for initial procedures: 17 (81%) of 21 initial and 10 (91%) of 11 secondary transseptal procedures were successful, and 72 (85%) of 85 initial and 4 (100%) of 4 secondary retrograde procedures were successful ($p = 0.01$). These results can be compared with those of Calkins et al. (3), who used the retrograde approach exclusively for left free wall pathways and who found (for all pathway locations) an 87% success rate for initial attempts but a 74% success rate for repeat attempts after initial failure. We speculate that in some instances, because of variation in the anatomy of the mitral annulus, some pathways may be more closely approached by one or the other method.

Our report differs from that of Natale et al. (15) in several important respects. In that series, they noted difficulty in catheter stabilization for anterolateral pathways because of the proximity to the left atrial appendage. We did not experience such difficulty, perhaps because we sometimes used a catheter with bidirectional tip deflection (EP Technology). Although Natale et al. suggest that the transseptal method is preferred for concealed pathways, we did not find a difference in approach-related success rate for concealed or manifest accessory pathways. Despite these technical differences, the overall success rate in their nonrandomized but consecutive series (retrograde 88%, transseptal 100%) is similar to ours.

Although in our experience both methods are equally likely to be successful, the order of the procedures is an important consideration, a technical phenomenon related to the anticoagulant status of the patient. If the retrograde method is attempted first and fails, the transseptal procedure should, in general, be performed during a separate session because it is inadvisable to attempt a transseptal needle puncture in a patient who has undergone heparinization. Although protamine can be given, its administration can be moderately time-consuming because therapy with protamine needs to be guided by repeated coagulation studies. Furthermore, the one patient who received protamine had a reaction to the medication, probably resulting in cathecholamine release, which in turn resulted in tachycardia that was difficult to control. Alternatively, when the transseptal method is attempted first and fails, the retrograde method can still be performed in the same session, even in a patient who has not undergone anticoagulation, provided that arterial access has been obtained at the beginning of the procedure. It is then a simple matter to change the arterial sheath to a larger size and proceed with a retrograde approach. Thus, all four patients with failed attempts at transseptal ablation had a successful retrograde procedure during the same session, whereas 9 of 11 patients with failed retrograde approaches required a separate session for their transseptal procedure.

Complications. Although the overall rate of complications was the same for both methods (6.7% for retrograde and 6.1% for transseptal), the most serious complication, dissection of the left coronary artery with myocardial infarction, occurred during a retrograde procedure. Other complications of the retrograde method have been described. In a report by Calkins et al. (3), 6 of 158 patients undergoing ablation of left-sided accessory pathways by the retrograde approach had significant complications, including coronary artery thrombosis in one, aortic valve perforation in one and vascular complications at the site of the arterial sheath in two, one of whom required surgical arterial repair. Minich et al. (7) detected a 30% incidence of new mild aortic regurgitation by Doppler echocardiography after retrograde ablation procedures, a finding noted in one of our patients. Although the long-term clinical implications of this finding are unknown, it points to the potential for untoward sequela when a blunt-tipped catheter is prolapsed across the delicate structure of the aortic valve and then manipulated in that position for a period of time. In addition, although these cases were not included in our series as complications as such, we found the retrograde method to be of limited utility in patients with a small or hypertrophic left ventricle or a tortuous or aneurysmal aorta because of difficulty in catheter manipulation. Indeed, these anatomic features accounted for 5 of the 11 patients with a failed retrograde approach who required crossover to a transseptal procedure.

Transseptal puncture performed during hemodynamic evaluation has in the past been associated with complications including perforation of the aorta, cardiac tamponade and death (12,16,17). However, most patients undergoing transseptal puncture for hemodynamic assessment have valvular or congenital heart disease and may have distorted septal anatomy. Such abnormalities are unlikely to be present in patients undergoing ablation because they are for the most part young and free from structural cardiac disease. Furthermore, we positioned catheters in the coronary sinus and aortic root in our patients to delineate the anterior and posterior extent of the intraatrial septum, adding an increased margin of safety. In addition, as was the case in eight of our patients, transseptal catheterization can be accomplished in a significant proportion of children by way of a patent foramen ovale, eliminating the risk of needle puncture. Van Hare and Silverman (18) showed that 21% of children without structural heart disease, 1 to 5 years of age, had patent foramina. In two of our patients we considered the transseptal method to have failed because we were unable to easily puncture the septum with the Brockenbrough needle. The availability of an alternative approach increased the safety of the method by allowing us to abandon transseptal puncture before possible complications occurred in these patients, who may have had abnormal septal anatomy.

Study limitations. Although we have reported a large consecutive series of patients, our study was not randomized. An additional limitation was the need for a physician trained in transseptal puncture to be available. Finally, we cannot know whether repeating the same method at a subsequent session, as reported by Calkins et al. (3), might not have been as successful as crossing over to the other method in those patients in whom arterial access was not the limiting factor.

Conclusions. The retrograde and transseptal approaches to ablation of left free wall accessory pathways have comparable success rates and rates of complications. They are complementary: If one method fails, the other should be attempted, yielding an overall success rate close to 100%. By attempting the transseptal procedure first, the retrograde procedure can be performed during the same session in the case of failure, whereas failure of the retrograde method generally necessitates a transseptal puncture during a separate session. Because of the higher rate of complications or technical failures with the retrograde method in children, the elderly and those with significant arterial or aortic valve disease or hypertrophic ventricles, the transseptal method should be the first used in these patients. The transseptal method does have as a potential limitation the need for someone trained in that technique; however, the invasive cardiologist performing the transseptal puncture and cannulation does not necessarily need to be the electrophysiologist who subsequently performs the mapping and ablation through the transseptal sheath. On the basis of our experience, it seems reasonable to recommend that invasive electrophysiologists should be comfortable with catheter manipulation, mapping and ablation along both the atrial and ventricular sides of the mitral valve and should either be trained in transseptal puncture or have access to an interventional cardiologist who is. However, because repeating the same approach during a separate session may ultimately be as successful as crossover to the other approach, and because of the limitations of our study noted, a randomized, prospective evaluation of the techniques seems warranted.

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